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# Identification of Bioactive Components in Various *Purslane* Species and Their Potential as Functional Food

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**A B S T R A C T**

Purslane is a wild plant considered a weed, but it contains various bioactive compounds with potential as functional foods. Several types of purslane commonly found in Indonesia include Portulaca oleracea L., Trianthema portulacastrum, Portulaca grandiflora, and Portulaca pilosa. This study aims to identify the chemical and bioactive components of various purslane types and their potential as functional foods. The functional effects analysed include antioxidant activity and in vitro inhibition of α-amylase. This study used a completely randomized design (CRD) with 3 replicates. The results showed that the chemical and bioactive components differed significantly among purslane species. The bioactive components identified included vitamin C, TDF (total dietary fiber), total phenols, omega-3, omega-6, and omega-9 fatty acids. All purslane flour species contained omega fatty acids dominated by omega-3, particularly α-linolenic acid (ALA, C18:3 ω-3), omega-6 dominated by linoleic acid (C18:2 ω-6), and omega-9 dominated by oleic acid (C18:1 ω-9c). The antioxidant activity of purslane ranged from 143.64 to 536.03 AAE/100 g, and its ability to inhibit α-amylase enzyme activity ranged from 64.99 to 82.05%. All purslane flours showed strong α-amylase inhibitory activity with $IC_{50} \leq 50$ µg/mL. These findings indicate that purslane species have high potential as functional food ingredients.

**Contribution to Sustainable Development Goals (SDGs):**
**SDG 2:** Zero Hunger
**SDG 3**: Good Health and Well-Being
**SDG 12:** Responsible Consumption and Production

## 1. INTRODUCTION

### *1.1. Research Background*

Purslane (*Portulaca* spp.) is a widely distributed wild plant that is often considered a weed due to its ability to grow easily in cultivated land and dry environments, as well as its high adaptability to adverse environmental conditions [1]. Despite its classification as a weed, purslane has gained increasing attention as a potential functional food owing to its nutritional value and diverse bioactive compounds. Globally, approximately 100 purslane species have been identified, several of which are commonly found in Indonesia, including *Portulaca oleracea* L., *Trianthema portulacastrum*, *Portulaca grandiflora* Hook., and *Portulaca pilosa* L. [2].

Previous studies have reported that purslane contains various bioactive compounds such as flavonoids, phenolics, tannins, saponins, alkaloids, glycosides, and vitamins, which contribute to its health-promoting properties [3], [4]. Among these species, P. oleracea L. has been extensively studied and is known to have relatively high levels of phenolics and flavonoids, along with strong antioxidant activity [5]. Phenolic compounds play a crucial role in mitigating oxidative stress, which is associated with the development of degenerative diseases.

In addition to its antioxidant properties, purslane has shown potential as an antidiabetic agent. Type 2 diabetes mellitus is characterised by insulin resistance and elevated blood glucose

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levels, resulting from impaired insulin secretion and environmental factors such as obesity and unhealthy dietary patterns [6]. In vitro evaluation of antidiabetic potential is commonly conducted by inhibiting carbohydrate-digesting enzymes, such as α-amylase and α-glucosidase. α-Amylase catalyzes the hydrolysis of starch into oligosaccharides, which are subsequently converted into glucose by α-glucosidase in the small intestine [7], [8]. Bioactive compounds in purslane have been reported to reduce postprandial blood glucose levels, suggesting their potential as natural antidiabetic agents [9].

Although numerous studies have focused on the antioxidant activity and omega-3 fatty acid content of purslane, comparative investigations involving multiple purslane species and their α-amylase inhibitory activity remain limited [10]–[12]. Therefore, this study aimed to identify the bioactive components of various purslane flours and evaluate their antioxidant activity and α-amylase inhibitory potential in vitro as a basis for developing purslane as a functional food ingredient.

### *1.2. Literature Review*

#### *1.2.1. Purslane*

*Portulaca oleracea* L. is a weed with a herbaceous form (non-woody stems) that has purple, round stems. Branching occurs at the base of the stem, where it contacts the soil. They can grow in open soil or under the shade of other plants and can also thrive at high altitudes [19]. *Trianthema portulacastrum* L. is a weed commonly known as Horse purslane. This plant can be found in soils along roadsides, in lawns, gardens, and residential areas. It is a C4 herbaceous species that spreads along the ground. *Trianthema portulacastrum* L. is a creeping, spreading, fleshy, and branching herb with thin, slightly hairy stems. Its leaves are single, fleshy, with unevenly arranged blades in an alternate pattern. Horse purslane has small, bisexual, solitary compound flowers that are white or bright pink [35]. *Portulaca grandiflora* Hook. is an ornamental and medicinal plant, commonly known as Bombay silk or moss rose [18]. *Portulaca grandiflora* has round, erect, dense, and reclining stems. The stems are light brown, with fine hairs at the nodes, and have a diameter of 2.7–5 mm. Moss rose leaves are single, sessile, green and shiny, succulent, somewhat soft, and thick. The leaf shape is linear-subulate, arranged alternately and spreading, with a width of 30–35 mm and a length of 1–3 cm. *Portulaca pilosa* L. is considered a weed and is the most commonly used krokot type for medicinal purposes. It has succulent, creeping stems that are pink or bright purple. The leaves are small, cylindrical, fleshy, and arranged alternately along the stem [43].

#### *1.2.2. Bioactive Compounds*

Bioactive compounds are active components in functional foods that facilitate metabolic reactions beneficial to health. Some bioactive components present in functional foods include carotenoids (such as β-carotene, lutein, and lycopene), dietary fiber (such as insoluble fiber, β-glucan, and soluble fiber), fatty acids (mono-unsaturated fatty acids [MUFA], polyunsaturated fatty acids [PUFA]), flavonoids, isothiocyanates, minerals, phenolic acids, polyols, prebiotics, probiotics, phytoestrogens, proteins, and vitamins (A, B1, B2, B3, B5, B6, B9, B12, biotin, C, D, and E) [47]. Bioactive compounds can provide health benefits such as anticancer effects, reduction of heart disorders, antihypertensive, antidiabetic, cardiovascular disease prevention, protection against oxidative stress, and brain health [41]

*Purslane* plants contain bioactive compounds that are beneficial for health, such as flavonoids, carotenoids, phenolics, and various vitamins, including vitamin C [48]. In addition, krokot plants also contain omega-3 and omega-6 fatty acids [19].

#### *1.2.3. Diabetes*

Diabetes mellitus (DM) is a disease characterised by disturbances in glucose metabolism and various metabolic disorders resulting from hormonal imbalances, leading to chronic complications in the kidneys, blood vessels, and eyes, accompanied by lesions in the basement membrane that indicate hyperglycemia. Diabetes mellitus is divided into two types: type 1 diabetes, caused by an autoimmune reaction against pancreatic islet proteins, and type 2 diabetes, caused by genetic factors that disrupt insulin secretion, insulin resistance, and environmental factors such as obesity, overeating or undereating, physical activity, stress, and aging [25]. Diabetes treatment can be carried out through two approaches: pharmacological and non-pharmacological. Non-pharmacological treatment involves improving healthy nutrient intake and lifestyle modifications for diabetic patients, such as exercising, avoiding alcohol consumption, and not smoking. Pharmacological treatment of diabetes involves consuming hypoglycemic drugs such as acarbose, metformin, glibenclamide, or using natural remedies that can reduce blood sugar levels.

### *1.3. Research Objective*

This study aims to determine the chemical composition and bioactive components of various purslane species and evaluate their poteintial as functional food ingredients.

## 2. MATERIALS AND METHODS

This research was conducted from February to October 2025 at the Food Analysis Laboratory, Universitas Pembangunan Nasional "Veteran" Jawa Timur, and PT. Saraswati Indo Genetech, Surabaya.

### 2.1. Materials

The main raw materials consisted of four purslane species: Portulaca oleracea L. obtained from rice fields in Parengan, Tuban; Trianthema portulacastrum L. and Portulaca grandiflora Hook. collected from Jombang; and Portulaca pilosa L. obtained from Blitar, East Java, Indonesia. Analytical-grade reagents included n-hexane, methanol, ethanol (96%), acetone, sulfuric acid ($H_2SO_4$), sodium chloride (NaCl), sodium carbonate ($Na_2CO_3$), sodium sulfate ($Na_2SO_4$), iodine solution (0.01 N), DPPH, Folin–Ciocalteu reagent, gallic acid, ascorbic acid, DNS reagent, phosphate buffer, α-amylase enzyme, and acarbose as a positive control.

### *2.2. Preparation of Purslane Flour*

Fresh purslane samples were washed under running water, and leaves and stems were separated. The plant materials were cut into small pieces to accelerate drying and dehydrated at 50 °C for 8 h using a food dehydrator. Dried samples were ground using a

blender and sieved through an 80-mesh sieve to obtain uniform flour.

### *2.3. Chemical Composition Analysis*

Moisture, ash, fat, and vitamin C contents were determined according to AOAC standard methods [13]. Total dietary fiber was analyzed using an enzymatic–gravimetric method as described by Adawiyah et al. [14].

### *2.4. Total Phenolic Content*

Total phenolic content (TPC) was determined using the Folin–Ciocalteu method with gallic acid as the standard. A 0.2 mL sample solution at a concentration of 1000 ppm was mixed with 1 mL of 7.5% $Na_2CO_3$ and incubated for 10 minutes. Subsequently, 1.25 mL of Folin–Ciocalteu reagent was added, followed by incubation for 30 minutes. A gallic acid standard curve was prepared at concentrations of 0, 5, 10, 15, 20, 25, 30, 35, and 40 ppm. The absorbance was then measured at a wavelength of 765 nm. Results were expressed as mg gallic acid equivalents (GAE) per 100 g sample [15].

### *2.5. Antioxidant Activity*

The samples were extracted using a water bath shaker at 60 °C and 200 rpm for 3 hours. Extraction was performed using 80% methanol with a sample-to-solvent ratio of 1:10 (w/v). The sample solution was diluted 20-fold. Subsequently, 1 mL of the diluted sample was mixed with 3 mL of 120 µM DPPH solution. Standard solutions were prepared at concentrations of 0, 5, 10, 15, 20, 25, 30, 35, and 40 ppm; 1 mL of each standard solution was mixed with 3 mL of DPPH solution. All solutions were vortexed and incubated in the dark for 60 minutes, after which absorbance was measured at 517 nm using a UV–Vis spectrophotometer.

### *2.6. α-Amylase Inhibitory Activity*

A series of sample dilutions was prepared at concentrations of 25, 50, 100, 250, and 500 mg/mL. Then, 300 µL of each sample solution was mixed with 300 µL of α-amylase solution (1000 U/mL) in 20 mM phosphate buffer (pH 6.9). The mixture was incubated at 37 °C for 10 minutes, followed by the addition of 300 µL of 0.25% starch solution prepared in 20 mM phosphate buffer (pH 6.9). The mixture was further incubated at 37 °C for 10 minutes. Subsequently, 50 µL of 60 mM 3,5-dinitrosalicylic acid (DNS) reagent was added. The reaction mixture was heated in a water bath for 5 minutes and then cooled to room temperature. The absorbance was measured at a wavelength of 540 nm. The percentage of enzyme inhibition by the sample was calculated using the following equation:

$$\text{Inhibition (\%)} = \frac{Abs.control - Abs.sample)}{Abs.control} \text{ x } 100\%$$

The sample concentrations, positive control, and percentage inhibition values were plotted on the x- and y-axes, respectively, to obtain a linear regression equation. From this equation, the y-intercept was used to determine the $IC_{50}$ (inhibitory concentration), while the x-value represented the extract concentration. The $IC_{50}$ value corresponds to the extract concentration required to inhibit 50% of α-amylase activity.

### *2.7. Statictical Analysis*

The experiment employed a completely randomized design (CRD) with three replications. Data were analyzed using one-way ANOVA followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level using IBM SPSS Statistics 27

## 3. RESULT AND DISCUSSION

### *3.1. Chemical Composition*

Based on the analysis results (Table 1), significant differences ($P \leq 0,05$) were observed among the different purslane species in terms of moisture, ash, and fat content.

**Table 1.** Chemical Composition of Purslane Plant Flour

| Components (%) | *Portulaca oleracea L.* | *Trianthema portulacastrum* | *Poirtulaca grandiflora Hook* | *Portulaca pilosa* |
|---|---|---|---|---|
| Moisture Content | $9.42^{c} \pm 0.502$ | $4.72^{a} \pm 0.150$ | $8.64^{b} \pm 0.287$ | $4,58^{a} \pm 0,158$ |
| Ash | $19.52^{b} \pm 0.449$ | $18.24^{a} \pm 0.177$ | $19.28^{b} \pm 0.417$ | $18,67^{a} \pm 0,740$ |
| Fat | $0.14^{a} \pm 0.016$ | $0.86^{d} \pm 0.054$ | $0.74^{c} \pm 0.024$ | $0,26^{b} \pm 0,080$ |

note: values followed by differents letters in the same row indicate significant differences ($P \leq 0,05$)

Moisture content is a testing parameter used to determine the percentage of water present in a material. According to Table 1, the purslane species had a significant effect on the moisture content of the resulting flour. Portulaca oleracea L. exhibited the highest moisture content (9.42%), while the lowest moisture contents were observed in Trianthema portulacastrum (4.72%) and Portulaca pilosa (4.58%). The higher moisture content in Portulaca oleracea L. is associated with its succulent morphology, with well-developed parenchyma tissue and large cell vacuoles. This tissue structure enables the plant to store a large amount of water as an adaptive mechanism for dry environments, resulting in greater residual moisture in the tissue [34]. In addition, the cell walls of *Portulaca oleracea* L. contain pectin and hemicellulose, which are hydrophilic in nature and enhance water-binding capacity, making bound water more difficult to remove during the drying process [45].

The average ash content of purslane plant flour (**Table 1**) ranged from 18.24% to 19.52%, with the highest value observed in *Portulaca oleracea* L. (19.52%) and the lowest in *Trianthema portulacastrum* (18.24%). The higher ash content in *Portulaca oleracea* L. is associated with its morphological characteristics as a succulent plant, with large vacuoles that function as storage sites for water and dissolved mineral ions. The accumulation of mineral ions within the vacuoles increases the mineral concentration in vegetative tissues, resulting in a higher inorganic residue after ashing.

Growth habitat also contributes to differences in ash content among species. *P. oleracea* L. grown in paddy fields with

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high soil moisture tends to develop a more extensive root system, thereby increasing the surface area for absorption and enhancing the efficiency of mineral uptake dissolved in soil water (Holz et al., 2024). In contrast, *T. portulacastrum*, which grows in dry environments such as home gardens, tends to prioritise mineral-use efficiency rather than large mineral accumulation, resulting in relatively lower mineral content in tissues and, consequently, lower ash content [13].

The average fat content of purslane flour (**Table 1**) in this study ranged from 0.14% to 0.86%, with the highest value observed in *Trianthema portulacastrum* (0.86%) and the lowest in Portulaca oleracea L. (0.14%). Although all samples were classified as having low fat content, interspecific variation indicates differences in physiological characteristics and lipid metabolism influenced by genetic factors and adaptation to growing environments [45]. The low fat content in *P. oleracea* L. is associated with its characteristics as a succulent plant possessing large vacuoles and high osmoregulatory activity. This condition prioritises carbon allocation from photosynthesis for the synthesis of water-soluble metabolites to maintain cell turgor and metabolic stability, thereby limiting the synthesis of neutral lipids such as triglycerides [22].

In succulent leaf tissues, lipids mainly function as structural components of cell membranes, such as phospholipids and galactolipids, rather than as energy reserves, which contributes to the low total fat content. Differences in fat content among species reflect variations in primary metabolic strategies, particularly in water management and carbon allocation, in which tissues with high moisture content tend to direct carbon toward hydrophilic metabolites rather than toward neutral lipid formation [22].

### *3.2. Bioactive Components*

Significant differences ($p < 0.05$) were observed among species for vitamin C, total dietary fiber, and total phenolic content (**Table 2**).

The average vitamin C content of purslane flour (**Table 2**) ranged from 12.59 to 46.31 mg/100 g, with the highest value observed in Trianthema portulacastrum (46.31 mg/100 g) and the lowest in Portulaca grandiflora (12.59 mg/100 g). Variations in vitamin C content among species indicate that growing environment and plant physiological conditions play important roles in regulating ascorbic acid biosynthesis and stability within plant tissues. The high vitamin C content in T. portulacastrum is associated with its growth habitat in relatively dry home-garden soils, which induces moderate drought stress. This condition increases the production of reactive oxygen species (ROS) and activates antioxidant defence mechanisms, including enhanced vitamin C biosynthesis via regulation of abscisic acid (ABA) signalling pathways [28].

Vitamin C functions as a primary antioxidant, neutralising ROS and protecting cellular membranes and proteins from oxidative damage, thereby leading to its increased accumulation as an adaptive response to environmental stress. In addition to water-stress factors, differences in vitamin C content are also influenced by plant tissue moisture levels. *P. grandiflora*, which exhibits higher moisture content, tends to experience more rapid ascorbate degradation due to increased water activity ($a_v$), which accelerates oxidative reactions of vitamin C [12]. In contrast, the lower moisture content in T. portulacastrum reduces the rate of ascorbate degradation due to limited water-molecule mobility and reduced oxidative enzyme activity, thereby enhancing vitamin C stability and accumulation.

The results showed that the average total dietary fiber content of purslane flour (**Table 2**) was relatively high for green vegetables, ranging from 38.05% to 46.90%, with the highest value observed in Portulaca grandiflora Hook. (46.90%) and the lowest in *Trianthema portulacastrum* (38.05%). The high dietary fibre content is closely associated with the plant cell wall composition, which is rich in structural polysaccharides such as cellulose, hemicellulose, and lignin, all of which directly contribute to total dietary fibre [36].

Environmental conditions influence differences in total dietary fibre content among species during growth and by plant physiological adaptation strategies. *T. portulacastrum*, which grows under dry soil conditions, tends to experience drought stress, leading to greater carbon allocation toward osmolyte synthesis to maintain osmotic balance rather than toward cell wall biosynthesis. This condition reduces the formation of structural polysaccharides, thereby resulting in lower dietary fibre content [15], [41]. In contrast, *P. grandiflora Hook*., which grows in highland areas with relatively low temperatures and more stable environmental conditions, exhibits a slower nocturnal respiration rate, allowing greater accumulation of photoassimilates. These photoassimilates are allocated to the formation of thicker, more complex cell walls, particularly in leaf and stem parenchyma tissues, thereby increasing the proportion of dietary fibre, especially insoluble fibre [7].

Phenolic compounds are secondary plant metabolites that play important roles in various plant functions and provide health benefits to humans, particularly as antioxidant agents [3]. In this study, the average total phenolic content of purslane flour (**Table 2**) ranged from 192.67 to 321.23 mg GAE/100 g, with the lowest value observed in Portulaca pilosa (192.67 mg GAE/100 g) and the highest in *Trianthema portulacastrum* (321.23 mg GAE/100 g). Differences in total phenolic content among species indicate that environmental conditions and plant physiological responses play crucial roles in regulating phenolic compound biosynthesis. The high total phenolic content in *T. portulacastrum* is associated with its growth habitat in relatively dry soils, which induces water stress and increases the production of reactive oxygen species (ROS). This condition activates phenolic biosynthetic pathways by enhancing the activity of key enzymes, such as phenylalanine ammonia-lyase (PAL), chalcone synthase (CHS), and related enzymes, thereby promoting the accumulation of phenolic compounds as a defence mechanism to neutralise ROS and maintain cell membrane stability [8], [23]. In addition to environmental stress factors, the accumulation of phenolic compounds is also influenced by the physiological function of plant organs. Leaves, as the primary photosynthetic organs, produce carbohydrates that serve as carbon sources for the formation of phenolic precursors via the shikimate pathway. Photosynthetically derived carbohydrates are metabolized into phosphoenolpyruvate (PEP) and erythrose-4-phosphate, which subsequently form intermediate compounds such as 3-deoxy-D-arabino-heptulosonate-7-phosphate (DAHP) and 3-dehydroshikimate, key precursors for various phenolic compounds [18]. The total phenolic content of purslane plants comprises various bioactive phenolic compounds, including

quercetin, kaempferol, ferulic acid, rutin, and caffeic acid, which contribute to the measured total phenolic values [3].

**Table 2.** Bioactive Components of Purslane Flour

| Components | *Portulaca oleracea L.* | *Trianthema portulacastrum* | *Portulaca grandiflora Hook.* | *Portu;aca pilosa* |
|---|---|---|---|---|
| Vitamin C (mg/100 g) | $0.032^{b} \pm 0.003$ | $0.047^{c} \pm 0.003$ | $0.012^{a} \pm 0.004$ | $0.021^{ab} \pm 0.006$ |
| Fiber (%) | $46.61^{b} \pm 2.004$ | $38.05^{a} \pm 1.610$ | $46.90^{b} \pm 2.763$ | $42.03^{ab} \pm 4.324$ |
| Total Phenol (mg GAE/100 g) | $296.15^{b} \pm 0.771$ | $321.67^{d} \pm 0.830$ | $317.15^{c} \pm 0.920$ | $192.67^{a} \pm 1.589$ |

Note: values followed by different letters in the same row indicate significant differences (P≤0,05)

**Table 3**. Total Omega Fatty Acid Content of Purslane Flour

| Spesies | Omega fatty acid (mg/100 g) | | |
|---|---|---|---|
| | Omega-3 | Omega-6 | Omega-9 |
| *Portulaca oleracea* L. | $1172.87 \pm 4.672^{a}$ | $885.17 \pm 2.344^{a}$ | $585.73 \pm 1.632^{a}$ |
| *Trianthema portulacastrum* | $859.33 \pm 8.852^{b}$ | $1466.78 \pm 5.314^{b}$ | $388.27 \pm 0.971^{b}$ |
| *Portulaca. grandiflora Hook.* | $1322.17 \pm 3.847^{c}$ | $590.80 \pm 1.015^{c}$ | $139.50 \pm 0.361^{c}$ |
| *Portulaca pilosa* | $1488.90 \pm 2.291^{d}$ | $954.50 \pm 2.443^{d}$ | $301.77 \pm 0.802^{d}$ |

Note: values followed by different letters in the same column indicate significant differences (P≤0,05)

**Table 4.** Types of Omega Fatty Acid in Purslane Flour Species

| Component | Content (mg/100 g) | | | |
|---|---|---|---|---|
| | *Portulaca oleracea L* | *Trianthema portulacastrum* | *Portulaca grandiflora Hook* | *Portulaca pilosa* |
| C14:0 (Miristic Acid) | 0.0191 | 0.0099 | 0.0130 | 0.0272 |
| C15:0 (Pentadekanoic Acid) | - | 0.0098 | 0.4802 | - |
| C16:0 (Palmitic Acid) | 0.7655 | 0.8020 | - | 0.8519 |
| C17:0 (Heptadecanoic) | - | - | - | 0.0345 |
| C18:0 (Stearic Acid) | 0.1591 | 0.2047 | 0.1936 | 0.3153 |
| C20:0 (Arachidic Acid) | - | 0.0457 | - | - |
| C22:0 (Behenoic Acid) | - | 0.0412 | 0.0263 | 0.0456 |
| C24:0 (Lignoseric Acid) | - | 0.0541 | 0.0890 | - |
| C16:1 (Palmitoleic Acid) | - | 0.0108 | 0.0454 | 0.0203 |
| C18:1 w9C (C-Oleic Acid) | 0.3883 | 0.5857 | 0.1395 | 0.3018 |
| C 18:2 w6C (C-Linoleic Acid) | 0.8852 | 1.4668 | 0.3819 | 0.9545 |
| C18:3 w6 ($\gamma$-linolenic Acid/w6) | - | - | 0.0274 | - |
| C18:3 w3 ( $\alpha$-linolenic Acid/w3) | 1.3741 | 0.8594 | 1.3235 | 1.4889 |
| C22:6 w3 (Dokoheksanoic Acid) | - | - | - | - |
| C20:5 w3 (Eikosapentaenoic Acid) | - | - | - | - |

Fatty acids in purslane plants are dominated by unsaturated fatty acids, particularly omega-3, omega-6, and omega-9, despite their relatively low total fat content. The average total omega-3 fatty acid content (**Table 3**) ranged from 859.33 to 1488.90 mg/100 g, with the highest value observed in Portulaca pilosa (1488.90 mg/100 g), predominantly composed of α-linolenic acid (ALA, C18:3 ω-3). The high omega-3 content is influenced by genetic factors and the regulation of fatty acid desaturase (FAD) enzymes that control the conversion of linoleic acid to ALA, as well as by environmental conditions such as lower nighttime temperatures, which induce an increased degree of lipid unsaturation to maintain cell membrane fluidity [45], [49].

The total omega-6 fatty acid content in *purslane* flour (**Table 3**) ranged from 590.50 to 1466.77 mg/100 g, with the highest value observed in *Trianthema portulacastrum* (1466.77 mg/100 g), predominantly composed of linoleic acid (C18:2 ω-6) (**Table 4**). The dominance of linoleic acid in this species is consistent with its lipid metabolic characteristics and previous findings in *T. portulacastrum* [8]. Meanwhile, omega-9 fatty acid content was relatively lower, ranging from 139.50 to 585.73 mg/100 g, compared with omega-3 and omega-6 fatty acids. Differences in omega fatty acid proportions among species reflect variations in plant physiological adaptation strategies to environmental conditions and structural requirements of cell membranes [33]. Although all species exhibited low total fat content, the fatty acid profile of purslane plants demonstrates high functional value due to the predominance of unsaturated fatty acids, particularly α-linolenic acid (omega-3) and linoleic acid (omega-6), which play important roles in cardiovascular health and glucose metabolism regulation [34]. In green plants, unsaturated fatty acids primarily function as structural lipids constituting chloroplast and cellular membranes rather than as energy reserves, owing to their role in maintaining membrane fluidity, photosystem stability, and efficient electron transfer during photosynthesis [45]. These findings confirm that *purslane* plants have potential as sources of bioactive omega fatty acids despite their low total fat content, with variations in fatty acid composition influenced by genetic characteristics and physiological adaptation to growing environments [31].


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### *3.3. Antioxidant Activity*

The antioxidant activity of purslane flour was evaluated using the DPPH method. Analysis of variance indicated that different purslane flour species exhibited significant differences ($P < 0.05$) in antioxidant activity.

**Table 5**. Antioxidant Activity of *Purslane* Flour

| Sample | Antioxidant (AAE/100 g) |
|---|---|
| *Portulaca pilosa* | $143.64 \pm 0.439^{a}$ |
| *Portulaca grandiflora hook* | $275.74 \pm 0.835^{b}$ |
| *Trianthema portulacastrum* | $384.49 \pm 1.857^{c}$ |
| *Portulaca oleracea* L. | $536.02 \pm 1.665^{d}$ |

note: values followed by different letters indicate significant differences (P≤0,05)

The antioxidant activity of purslane flour analysed in this study (Table 5) ranged from 143.64 to 536.03 mg AAE/100 g, with an average of 286.33 mg AAE/100 g. *Portulaca oleracea* L. exhibited the highest antioxidant activity (536.03 mg AAE/100 g), while the lowest value was observed in *Portulaca pilosa* (143.64 mg AAE/100 g). Differences in antioxidant activity among species indicate the influence of growing habitat, environmental stress, and plant morphological and physiological characteristics on the formation and stability of antioxidant compounds [4], [24].

The high antioxidant activity observed in *P. oleracea* L. is presumed to be associated with its growth in humid environments, which may induce oxidative stress and increase endogenous reactive oxygen species (ROS) production. This condition stimulates secondary metabolite pathways, particularly the synthesis of phenolic and flavonoid compounds, as part of the plant's defense mechanism against oxidative stress [8]. Phenolic compounds act as antioxidants through hydrogen atom donation mechanisms, which are influenced by the number of hydroxyl groups and the conjugated bond systems within aromatic rings.

However, the results of this study indicate that antioxidant activity does not always correlate positively with total phenolic content. *T. portulacastrum* exhibited the highest total phenolic content but relatively lower antioxidant activity, suggesting the contribution of other bioactive compounds to overall antioxidant capacity. This finding is consistent with previous reports indicating that antioxidant activity and phenolic and flavonoid contents in different *purslane* varieties do not always correlate positively [18]. This phenomenon may be attributed to the role of other secondary metabolites present in different parts of the purslane plant. The high antioxidant activity in P. oleracea L. is also presumed to be influenced by its relatively high omega-3 fatty acid (α-linolenic acid, ALA) content. ALA contributes to the suppression of ROS by stabilising lipid membranes and activating endogenous antioxidant defence systems, including the Nrf2/HO-1 pathway, thereby enhancing biological antioxidant capacity and cellular protection against oxidative damage [2], [39].

### *3.4.* Inhibitor of Purslane Plant Extract on *α-Amylase Activity*

In vitro antidiabetic activity was evaluated by measuring the ability of each purslane flour species to inhibit α-amylase activity. Based on the analysis of variance, significant differences ($P < 0.05$) were observed among the different purslane species in terms of α-amylase inhibitory activity of purslane flour.

The results of α-amylase inhibitory activity testing (Table 6) using the DNS method, with acarbose as a positive control, showed that increasing sample concentration was directly proportional to the percentage of inhibition. At a concentration of 500 ppm, the average inhibition of *purslane* flour ranged from 64.99% to 77.00%, while acarbose exhibited the highest inhibition of 82.05%. A high percentage of inhibition indicates the ability of the samples to reduce α-amylase catalytic activity, thereby potentially slowing the hydrolysis of starch into simple sugars. Flour from *Portulaca oleracea* L. exhibited the highest inhibitory activity among the purslane species, which correlated with its relatively high total dietary fiber content. Dietary fiber can form a physical barrier and increase the viscosity of the reaction medium, thereby reducing enzyme accessibility to the starch substrate. In addition, structural fibre components, such as cellulose, hemicellulose, and lignin, may simultaneously interact with the enzyme and starch, forming complexes that inhibit the catalytic activity of α-amylase [47]. Antioxidant activity also contributes to α-amylase inhibition, as phenolic compounds can bind to amino acid residues at the enzyme's active or allosteric sites through hydrogen bonding and hydrophobic interactions, thereby reducing the efficiency of starch hydrolysis [26].

**Table 6.** Inhibitory Activity of Purslane against *α*-Amylase Enzyme Activity

| Enzyme concentration (ppm) | *α*-Amilase Inhibitory Activity (%) | | | | |
|---|---|---|---|---|---|
| | *Portulaca oleracea* L. | *Trianthema portulacastrum* | *Portulaca grandiflora Hook* | *Portu;aca pilosa* | Acarbose |
| 25 | $3.34 \pm 0.409$ | $2.36 \pm 0.337$ | $4.99 \pm 0.312$ | $5.14 \pm 0.312$ | $4.15 \pm 0.239$ |
| 50 | $9.11 \pm 0.708$ | $12.29 \pm 0.382$ | $14.58 \pm 0.288$ | $10.59 \pm 0.288$ | $25.04 \pm 0.282$ |
| 100 | $21.62 \pm 0.454$ | $17.73 \pm 0.318$ | $30.01 \pm 0.375$ | $17.70 \pm 0.375$ | $30.44 \pm 0.288$ |
| 250 | $36.95 \pm 0.364$ | $34.48 \pm 0.416$ | $41.26 \pm 0.410$ | $24.44 \pm 0.410$ | $51.75 \pm 0.388$ |
| 500 | $77.00 \pm 0.377$ | $76.44 \pm 0.398$ | $74.90 \pm 0.389$ | $64.99 \pm 0.389$ | $82.05 \pm 0.417$ |

note: Values followed by different letters in the same row indicate significant differences (P≤0,05)

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## 4. CONCLUSION

The differences among purslane plant species significantly affected the chemical composition of purslane flour ($P < 0.05$). Portulaca oleracea exhibited the highest moisture content (9.42%) and the highest ash content (19.52%), whereas the highest fat content was observed in *Trianthema portulacastrum* (0.86%). Moreover, purslane species also significantly ($P \leq 0.05$) influenced the bioactive component content of purslane flour. *T. portulacastrum* showed the highest vitamin C content (46.31 mg/100 g) and the highest total phenolic content (321.67 mg GAE/100 g), while the

highest total dietary fiber was found in *Portulaca grandiflora* Hook. (46.90%). All purslane flour species contained omega fatty acids dominated by omega-3, particularly α-linolenic acid (ALA, C18:3 ω-3), omega-6 dominated by linoleic acid (C18:2 ω-6), and omega-9 dominated by oleic acid (C18:1 ω-9c). In vitro bioactivity assays revealed that P. oleracea L. exhibited the highest antioxidant activity (536.03 mg AAE/100 g), and all purslane flour types were capable of inhibiting α-amylase activity with $IC_{50}$ values ≤ 50 μg/mL, indicating their potential as functional food ingredients.

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